北海道大学

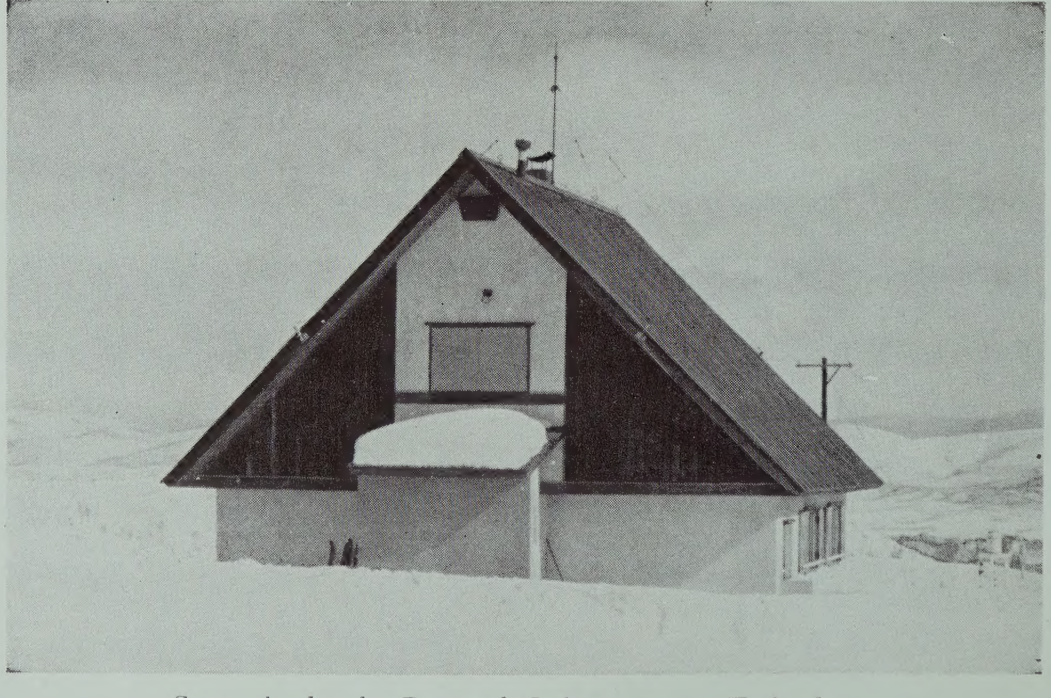
低温科学研究所

THE INSTITUTE OF LOW TEMPERATURE SCIENCE

HOKKAIDO UNIVERSITY
SAPPORO, JAPAN

1975

Sea Ice Research Laboratory in *Mombetsu*

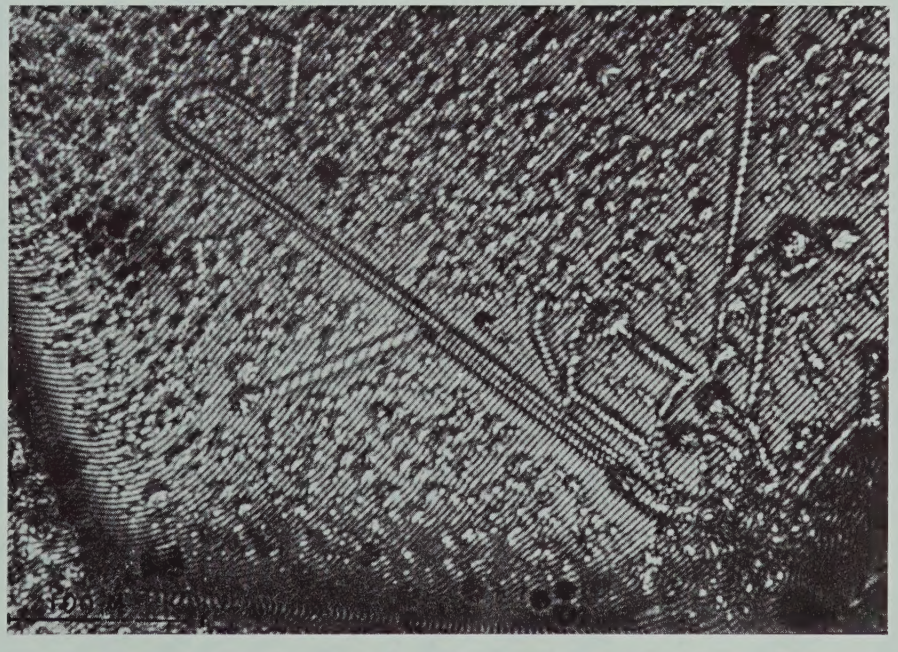


Snow Avalanche Research Laboratory in *Toikanbetsu*

THE INSTITUTE OF LOW TEMPERATURE SCIENCE
HOKKAIDO UNIVERSITY

The origin of establishment of the Institute of Low Temperature Science may have been in 1935, when a small cold room was constructed by Dr. Ukichiro Nakaya on the Hokkido University campus to conduct research work of artificial snow crystals. Around that time, Dr. Sôichi Yanagi and his collaborators were making research on death from cold. Such pioneering work led to the foundation of the Institute of Low Temperature Science at Hokkaido University on 25th November 1941. The purpose of the Institute was to study natural phenomena occurring at climatic low temperatures in Hokkaido from a view point of basic science. The Institute was composed of four physical (Physics, Applied Physics, Meteorology and Oceanography) and two biological (Biology and Medicine) sections. Dr. Kan Oguma, Professor at the Faculty of Science, Hokkaido University, contributed largely to establishment of the Institute. He served as the first Director for seven years.

Since Hokkaido is located in the northern part of Japan, various

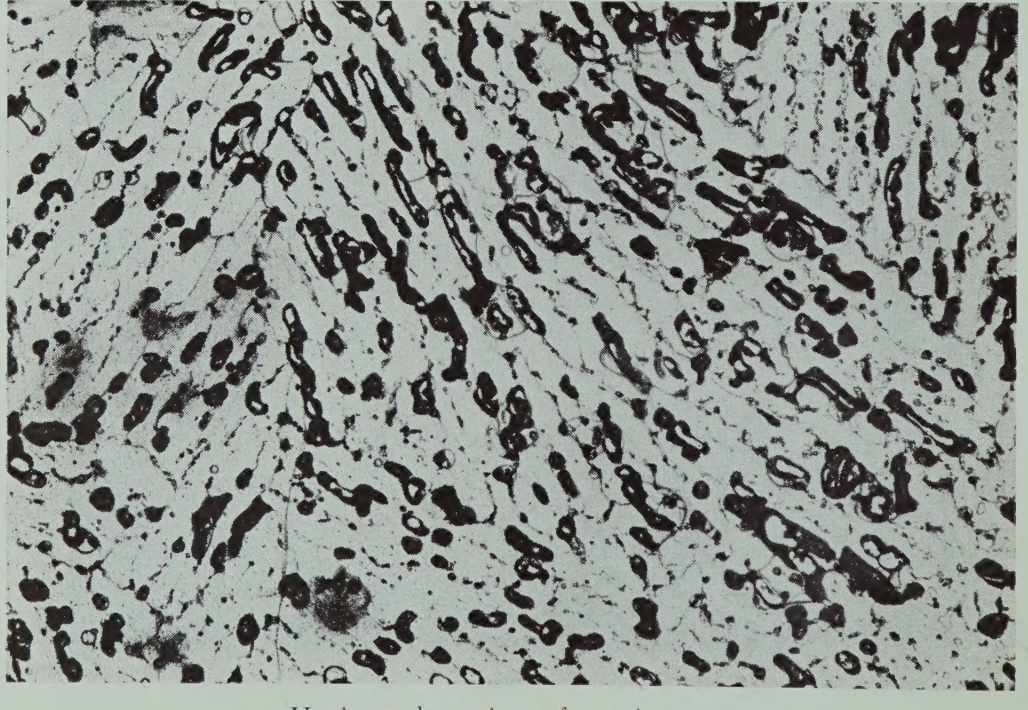


Interferogram of etched basal surface of ice. Etch channels created by the dislocation movements developed to 1010 direction

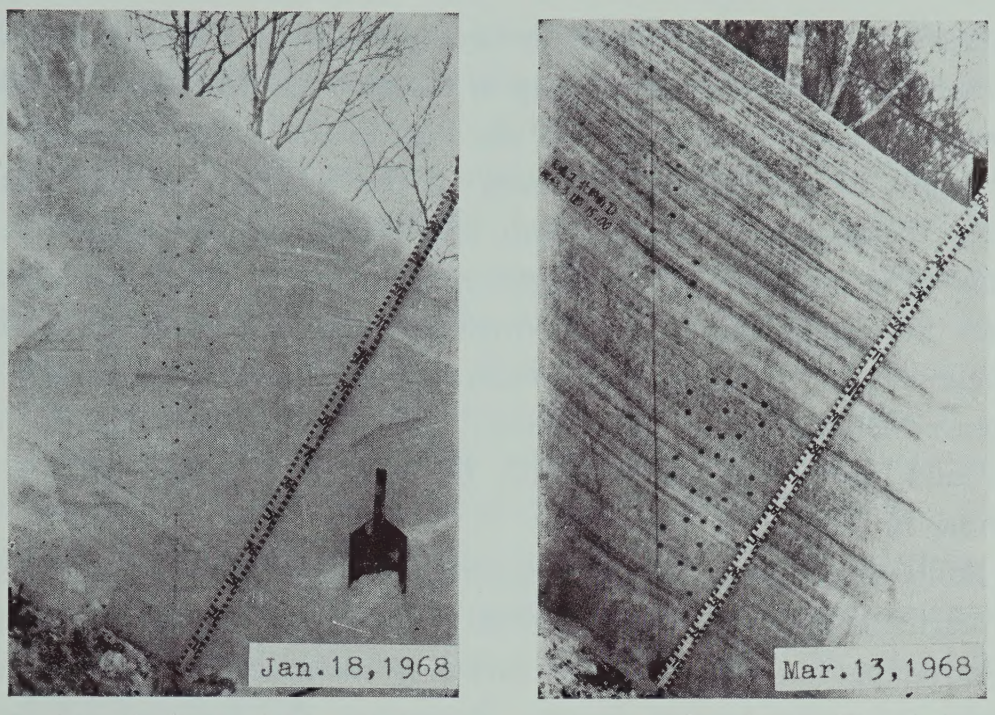
problems involving human life arose from heavy snow falls and severe cold. Because of the social requirements in postwar Japan, efforts were also made to find solutions for practical problems. Several research sections, namely Snow Damage, Frost Heaving, Frost Injury in Plant and Snow Melt, were added to the Institute over eight years from 1963.

After Dr. Nakaya's famous work on snow crystals, a number of glaciological studies were developed in the Institute. One of the most remarkable contributions among the work of this period may be the studies on physical properties of deposited snow by Prof. Zyungo Yosida and his group. Their work later extended into various fields of glaciology such as snow avalanche mechanics, frost heaving mechanism and snow hydrology. Concurrently numerous basic works on ice crystals and deposited snow were being conducted from a view point of solid state physics. More recently, various works on the structure and the metamorphism of snow and ice are being performed.

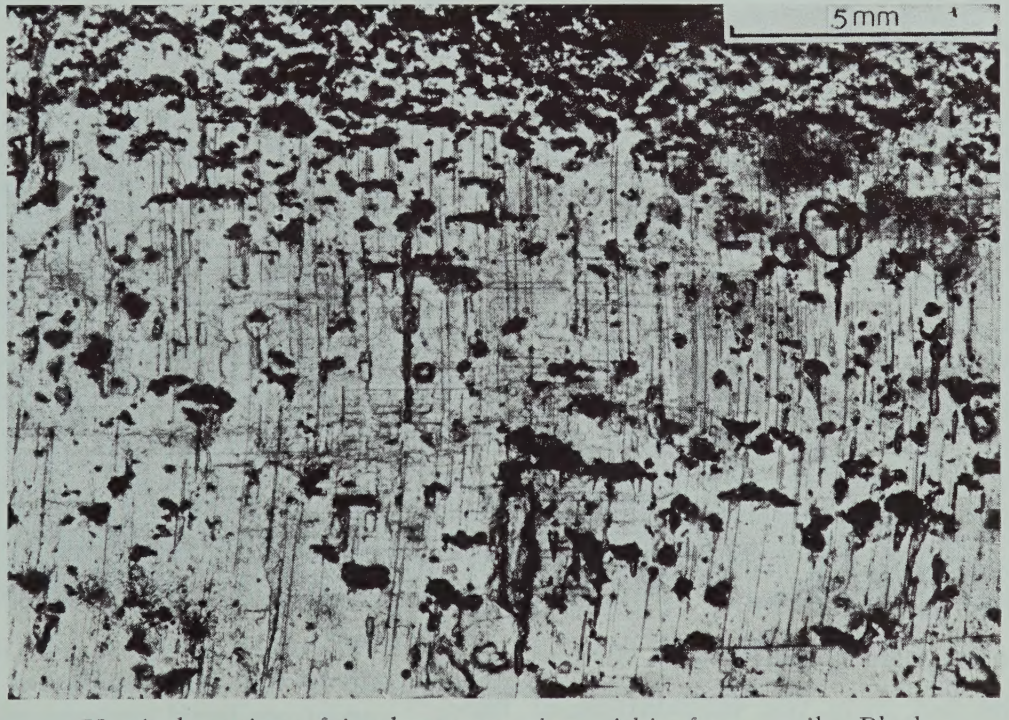
Sea ice studies undertaken by Prof. Takaharu Fukutomi and his group from 1944 brought the establishment of a sea ice research station as one of the branch laboratories of the Institute in Mombetsu city on the Okhotsk Sea coast in 1965. This laboratory has a radar system to



Horizontal section of sea ice 3×



Observation of plastic deformation of snow cover on the slope: Fine holes were bored in the snow cover, and their displacement were observed with lapse of time. Circular arrangement of the holes (*left picture*) were deformed into an elliptic arrangement, i. e., strain ellipse (*right picture*) and a vertical line arrangement (*left*) was deformed into a slant curve arrangement (lower half of *right*,) in 55 days. (Holes in the upper half of *right* were bored in the newly deposited snow layer, 13 and 27 days after the first boring, respectively)



Vertical section of ice lens appearing within frozen soil. Black portion, soil; white portion, ice; longitudinal line, air bubble

monitor drifting sea ice which descends along the Okhotsk Sea coast.

Agriculture and stock-farming in the east Pacific coast of Hokkaido is remarkably hindered by dense sea fogs in the summer season. For four years from 1950, the majority of the members of the Institute of Low Temperature Science, both in physical and biological research groups were engaged in investigations on sea fog and fog-preventing forests in cooperation with scientists of other Faculties of Hokkaido University, the Forestry Department of Hokkaido Government and Sapporo Meteorological Observatory. The results obtained were compiled and published as STUDIES ON FOGS (T. Hori *ed.*) by the Institute in 1953.

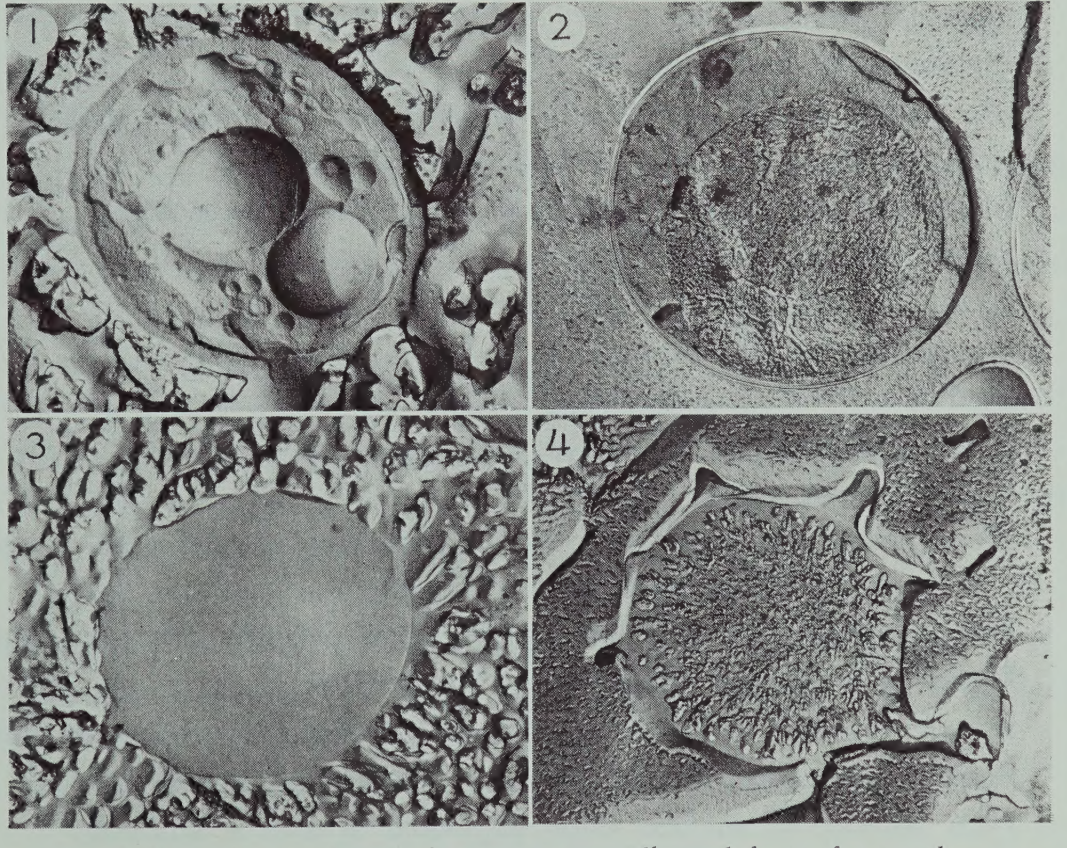
Biological research in the Institute of Low Temperature Science was originally devoted to fundamental problems involving life and death at low temperatures rather than practical research for the prevention of cold injury in human being. Regarding the freezing process of living organisms a considerable amount of works was published by Prof. Kiyoshi Aoki and his group, knowledge on behavior of cells in animals and plants during freezing was remarkably increased. As a result of above work, a simple method to keep various plants and insects alive under extremely low artificial temperatures was developed after 1956. Electoron microscopy of frozen specimens of various biological and medical materials was greatly advanced by Prof. Tokio Nei and his associates. They also have been working for many years on the mechanism of freeze-drying of biological materials.

A cecropia silkworm emerged from a pupa frozen-thawed at and from liquid nitrogen temperature

Since the biochemical approach has recently become one of the most common methods to elucidate biological problems at low temperatures, the Biochemistry section was newly added to the Institute in 1973. Our biological research has recently been directed towards not only the elucidation of biochemical and biophysical mechanisms

of freezing injury in a variety of organisms, but also various little-known fields of low temperature biology from a view point of ecological, developmental and differentiation biology.

One of the distinguished contributions of the Institute may be the International Conference on Low Temperature Science held in Sapporo in August 1966. This conference was held celebrating the 25th aniversary of the establishment of the Institute. One hundred and thirty scientists, including fifty two foreign scientists from ten countries, participated in the conference. The proceedings of the conference, namely PHYSICS OF SNOW AND ICE (H. Ôura *ed.*) and CELLULAR INJURY AND RESISTANCE IN FREEZING ORGANISMS (É. Asahina *ed*). were published in 1967 by the Institute. The success of this conference has made the Institute international and since then we have widened our research activities to extend beyond the boundary of Japan.



Cells in the specimens, frozen very rapidly and freeze-fractured

(1) An yeast cell with 30% glycerol. 10,000× (2) an yeast cell without glycerol, intracellular freezing. 10,000× (3) an erythrocyte with 30% glycerol. 6,000× (4) an erythrocyte without glycerol, intracellular freezing. 6,000×

The Institute now has eleven research sections: Physics, Applied Physics, Meteorology, Oceanography, Snow Damage, Frost Heaving, Snow Melt, Frost Injury in Plants, Biology, Medicine and Biochemistry. A number of laboratory experiments involving the properties and behavior of substances and organisms are being carried out under both climatic and artificial low temperature conditions. A wide variety of field work has also been carried out in various locations over the globe from temperate to polar regions of both Arctic and Antarctica.

Current Projects

Physical and Geophysical Studies:

Study of snow crystals.
Dielectric properties of single crystal of ice.
Dislocation movements and etching process of ice.
X-ray studies on crystal imperfections in ice.
Thermal stress in ice.
Metamorphism of snow.
Mechanical properties of snow at and near its melting point.
Friction between snow, ice and other materials.
Plastic deformation of snow and ice around an obstacle.
Stress wave propagation in snow.
Electrical properties of snow and ice.
Studies on blowing snow.
Studies on turbulent boundary layer.
Experimental study of stress distribution in the snow cover on mountain slope.
Measurement of speed and impact pressure of naturally released (high speed) airborne type avalanche.
Metamorphosis and mechanical properties of snow cover on slopes.
Percolation of melt water into a snow cover.
Special cooling of lower atmosphere at basins with snow cover.
Snow melt run-off and variation of stream temperature.
Heat balance of surface snow deposited around a building.
Snow drift preventing efficiency of snow fences.
Snow and ice accretion on power lines.
Snow melt by chloride compounds and its influence upon friction

between snow and vehicle tire.

Nature of deposited snow on roads.

The freeze-melting process of soil.

Water migration in the soil during frost heaving.

Heaving force of frozen ground.

Thermal stress in frozen ground.

Microstructure and mechanical property of frozen soil.

Crystal structure and frost susceptibility of powder.

Weathering of the rock in cold climates.

Physical properties of sea ice.

Thermo-haline convection of sea water due to the growth of sea ice.

Prevention of icing on boat.

Observation of drifting sea ice by means of ice radar net work.

The movement of drifting sea ice.

Properties of micro-wave emmisivity of drifting sea ice.

Studies of Soya warm current.

Biological and Medical Studies:

Denaturation of enzyme protein by freezing and drying.

Mechanism of metabolic regulation adapted to cold environment.

Freezing injury in liver mitochondrial membranes.

Structural alteration of cellular membranes of yeast and erythrocyte by freezing.

Supercooling injury in a ciliate protozoa.

Ice formation in rapidly cooled mammalian cells.

Freezing resistance in the egg cells of the sea urchin.

Freezing storage of cultured plant cells in liquid nitrogen with reference to gene pool.

Cold acclimation in plants.

Temporal control of metabolic activities in wintering poplar.

Freezing resistance of plants in different climates with reference to plant distribution.

Physiology and ecology of cold resistant insects.

Oversea Field Research

The Institute of Low Temperature Science was in good cooperation with the Japanese Antarctic Research Expedition (JARE) since the

embryo stage of JARE. The Institute has been sending one or two scientists to JARE every year to make preliminary and general surveys of the ice sheet in East Antarctica. Systematic glaciological observations on mass budget and heat balance in the Mizuho Plateau were started from JARE-9 in 1969 in close connection with other Earth Science Projects. Deep boring of the ice sheet was made over a period of a few years at Mizuho Camp since 1970. The obtained samples have been used for the analysis of ice core at our Institute.

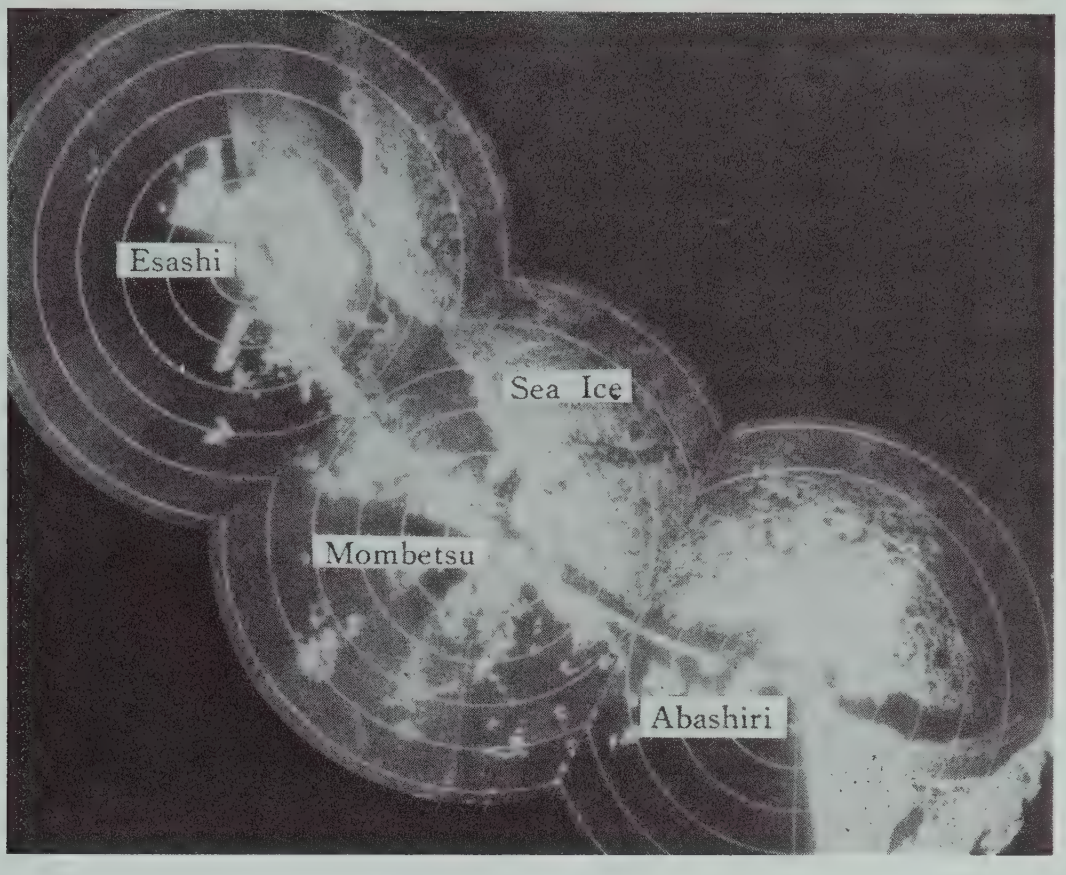
Since 1960, research groups from the Institute have been carrying out glaciological and biological work also in the Arctic regions. Field studies on glaciers, sea ice, frozen ground and Arctic biology have been made in Alaska, Arctic Canada and Siberia. Some of these projects were cooperated with other research groups or organizations such as Water Research Institute at Nagoya University, Department of Applied Physics at Hokkaido University, Geophysical Institute and Institute of Water Resources at the University of Alaska, Department of Inland Water Research in Canada, Arctic Ice Dynamics Joint Experiment, Yakutsk Permafrost Research Institute in Siberia, and so on.

Topics of oversea field research carried out during past three years, exclusive of JARE:

Sea ice research in Alaska. March 1973.
Ice study in Barrow, Alaska. October-November 1973.
Scientific expedition on permafrost (including forest ecology) in Alaska and North Canada. June-July 1974.
Sea ice research expedition in Gulf of Bothnia. March 1975.

Research Facilities Attached to the Institute

The Institute has three separate laboratories, the first for sea ice research in Mombetsu, the second for avalanche research in Toikanbetsu and the third for frost heaving research in Tomakomai. Sea Ice Research Laboratory has a radar system for the sole purpose of ice observation, the first and the only one in the world. Three radar antennas were installed along the Okhotsk Sea coast of Hokkaido, *i. e.*, from north to south, on Mt. Tokushibetsu (430 m above sea level) in Esashi, on Mt. Oyama (300 m) in Mombetsu, and at Cape Notoro



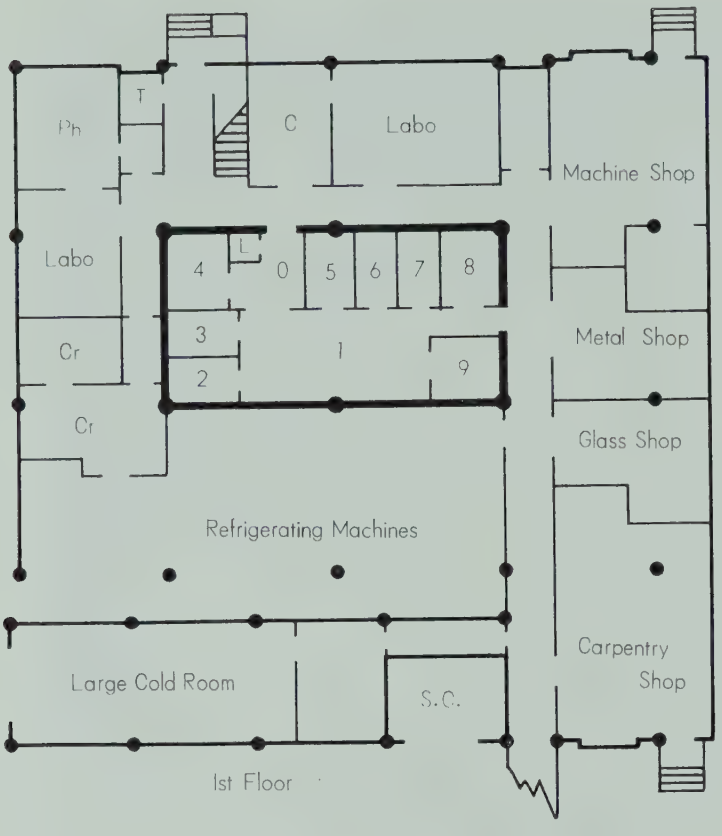
Radar echoes from drift ice (Feb. 27. 1970). Range circles are 5 nautical miles apart

(200 m) in Abashiri, to cover an area of 60–80 km in width along the entire coast line.

Cold Rooms

In the laboratory building completed in March 1969, there are thirty two cold rooms, which may be divided into four groups, *i. e.* the first floor block, the second floor block, a wind tunnel room with an annex, and a large cold room, their floor areas being 125, 260, 157 and 86 m^2, respectively.

The first floor block consists of an entrance, a common preparatory room (45 m^2), and eight small rooms (each about 8 m^2) equipped with various kinds of testing machines, while the second floor block has an entrance, a common preparatory room (29 m^2), two medium rooms (28 m^2 and 33 m^2), and sixteen small rooms, of which two are installed with an X-ray diffract meter and a micro-beam X-ray apparatus, two are for isotope treatment, and two are for handling poisonous chemicals and are specially designed to meet the necessary safety conditions.

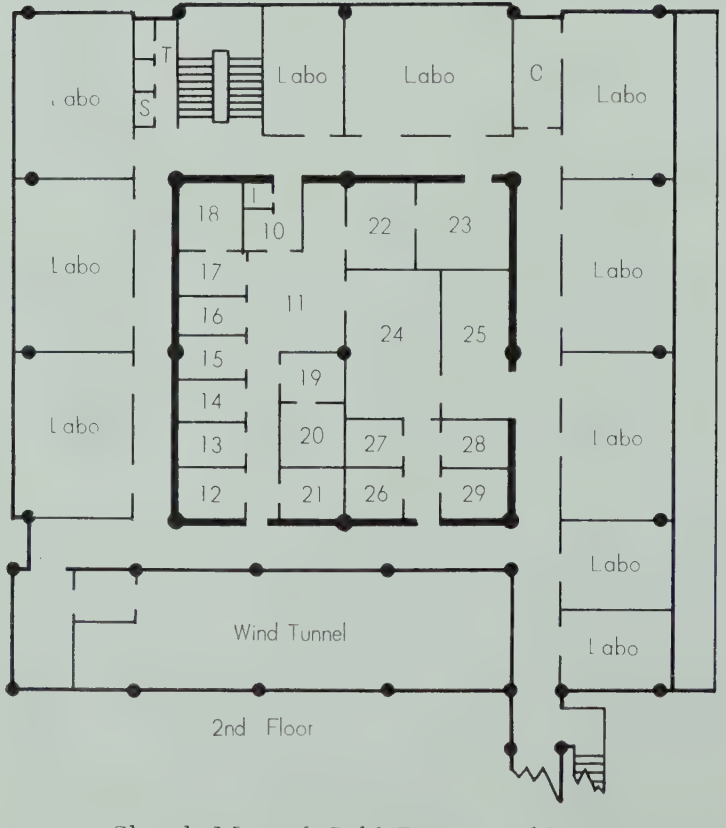


1st Floor

C	Cold box
Cr	Control room
Labo	Laboratory
Ph	Phytotrone
S. C.	Snow collector for wind tunnel, 2nd floor
T	Toilet

Cold rooms

0	Entrance
1	Common preparatory room
2–9	Small rooms
L	Lift



2nd Floor

C	Cold box
S	Shower
T	Toilet

Cold rooms

10	Entrance
11	Common preparatory room
12–16, 21, 26, 27	Small rooms
17, 18	Thin-section process rooms
19	−60°C room
20	−80°C room
22, 23	X-ray rooms
24	Medium room with brine outlets
25	Medium room for refrigerated microscopes
L	Lift

Sketch Map of Cold Room Building

The wind tunnel room has a Göttingen type wind tunnel for studying the drift of snow. The tunnel has a cyclonic collector to prevent drifting snow to recirculate and has an observation space of $50 \times 50 \times 800\,cm^3$. The maximum wind speed is 40 m/s.

Five R22 freezing machines make −28°C and −48°C brine (trichloroethylene, $CHClCCl_2$), which in turn are circulated through heat exchangers in the rooms to cool them down to −20°C and −40°C. An indirect cooling system has been adopted in order to ensure an easy control of room temperatures. Two small rooms on the second floor block have additional booster heat exchangers driven directly by an R13 freezing machine and can be cooled down to −60°C and −80°C, respectively. For the purpose of local cooling, there are brine outlets and inlets in the two medium rooms and the two X-ray rooms.

The room temperatures can be designated at the control panel in the controlling room and can be automatically maintained at ±1°C of the assigned temperatures.

The common preparatory rooms, the medium rooms, and the rooms for using poisonous chemicals can be forcibly ventilated with −20°C dry air, while small rooms are ventilated by natural convection through ventilation holes connecting them to the common preparatory rooms.

Table of Freezing Machines

Use	High Stage	Low Stage No. 1	Low Stage No. 2	Deep Freeze
Refrigerant	R 22	R 22	R 22	R 13
Condensing Temperature (°C)	30	–	—	—
Intermediate Pressure Saturated Temp. (°C)	—	−32.5	−32.5	−40
Saturated Suction Temp. (°C)	−35	−55	−50	−93
Refrigerating Capacity (kcal/h)	31,500	23,700	46,500	5,320
Refrigerating Capacity (J. R. T.)	9.5	7.2	14.0	1.6
Compressing Power (kW)	26.3	9.26	17.01	19.5
Electric Motor (kW)	30.0	15.0	22.0	22.0
Number	3	1	1	1

Publications

Results obtained by the investigations at the Institute of Low Temperature Science are published in Japanese with English summaries in the journal of "低温科学" (*Teionkagaku*, Low Temperature Science, physics series and biology series) and in English in "Contributions from the Institute of Low Temperature Science" series A (physics and geophysics) and series B (biology and medicine) both edited by the Institute. The latest publication was Vol. 32 for both the physics series and biology series of the former and series A No. 26 and series B No. 18 for the latter.

Scientists

(47 in total)

Director: Dr. Daisuke KUROIWA

(1) Physics Section:
Prof. Dr. Daisuke KUROIWA, Ass. Prof. Dr. Teisaku KOBAYASHI, Assist. Dr. Shigenao SUZUKI, Tomomi YAMADA

(2) Applied Physics Section:
Prof. Dr. Gorow WAKAHAMA, Ass. Prof. Dr. Kazuo FUJINO, Assist. Yasoichi ENDO, Yukiko MIZUNO, Katutosi TUSIMA

(3) Meteorology Section:
Prof. Dr. Tamotsu ISHIDA, Ass. Prof. Dr. Norikazu MAENO, Assist. Shun-ichi KOBAYASHI, Renji NARUSE

(4) Oceanography Section:
Prof. Dr. Tadashi TABATA, Ass. Prof. Dr. Nobuo ONO, Assist. Masaaki WAKATSUCHI, Takatoshi TAKIZAWA

(5) Snow Damage Section:
Prof. Dr. Tosio HUZIOKA, Ass. Prof. Dr. Hiromu SHIMIZU, Assist. Dr. Eiji AKITAYA, Hideki NARITA

(6) Frost Heaving Section:
Prof. Dr. Seiiti KINOSITA, Ass. Prof. Dr. Yoshio SUZUKI, Assist. Kaoru HORIGUCHI, Masami FUKUDA

(7) Snow Melt Section:
Prof. Dr. Kenji KOJIMA, Ass. Prof. Dr. Daiji KOBAYASHI,

Assist. Hideaki ABURAKAWA, Nobuyoshi ISHIKAWA

(8) Section of Frost Injury in Plants :

Prof. Dr. Akira SAKAI, Ass. Prof. Dr. Shonosuke SAGISAKA, Assist. Dr. Shizuo YOSHIDA, Kouji ÔTSUKA

(9) Biology Section :

Prof. Dr. Éizo ASAHINA, Ass. Prof. Dr. Ichiro TAKEHARA, Lecturer Dr. Kouzou TANNO, Assist. Kimio SHIMADA

(10) Medical Section :

Prof. Dr. Tokio NEI, Ass. Prof. Dr. Hiroshi SOUZU, Lecturer Dr. Naofumi HANAFUSA, Assist. Tadashi ARAKI,

(11) Biochemistry Section :

Prof. Dr. Haruo CHINO, Ass. Prof. Dr. Motonori HOSHI, Assist. Tsuneo MORIYA, Chihiro KATAGIRI

(12) Sea Ice Research Laboratory :

Prof. Dr. Tadashi TABATA, Ass. Prof. Dr. Masaaki AOTA, Assist. Toshiyuki KAWAMURA

Educational Work

The Institute is open to the postgraduate students from various Faculties in Hokkaido University. Master and Doctor courses can be arranged in Physics, Geophysics, Chemistry, Biology and Medicine.

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